NRL Memorandum Report 1176

# HIGH FREQUENCY RADAR OBSERVATIONS MADE ON TRAILBLAZER 1G

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RADAR DIVISION

1 June 1961





U. S. NAVAL RESEARCH LABORATORY
Washington, D.C.

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# HIGH FREQUENCY RADAR OBSERVATIONS MADE ON TRAILBLAZER 1G

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## ABSTRACT

Radar observations were made at the Naval Research Laboratory of the phenomena associated with the reentry body of the Trailblazer 1G firing. Post flight spectrum analysis of doppler records evidences a firm detection capability predicated on the difference in doppler-time characteristics of the Trailblazer reentry body from those of normally occurring meteor reflections. Comparison of the 1G results with those of the Trailblazer 1C and 1E firings indicates a difference in trajectory geometry.

## PROBLEM STATUS

This is an interim report on one phase of the problem; work is continuing on this and other phases.

## AUTHORIZATION

NRL Problem R02-23
Project RF 001-02-41-4007

# HIGH FREQUENCY RADAR OBSERVATIONS MADE ON TRAILBLAZER 1G

The purpose of the Trailblazer series of rocket launches is to study the physical phenomena which occur during reentry of high speed objects into the earth's atmosphere. Trailblazer 1G was launched from Wallops Island, Virginia, and it employed seven stages. Three stages fired up and then four fired down with the last two providing the highest speed reentry bodies. These two bodies consisted of a five inch titanium sphere and a steel pellet whose largest dimension was roughly 3/4 inch.

The HF radar used to observe Trailblazer 1G reentry effects was an NRL conventional coherent doppler radar. The characteristics were as follows:

| | |
|---|---|
| Power | 40 KW peak |
| Frequency | 26.6 mc |
| Pulse Length | 250 μs |
| Repetition Rate | 250 pps |
| Antenna | 12 db one way gain (pair of six element yagis stacked vertically) |

The raw received signals were amplified, coherently converted to a zero frequency IF, and then recorded on magnetic tape. The tape was later spectrum analyzed using a Kay Vibralyzer.

Trailblazer 1G was launched about 12:56:20 AM EST, 21 April 1961. Man-made noise was at a relatively low level, no backscatter returns via the ionosphere were present, however, returns from meteor trails were noted at a relatively high rate. Observations on an A-Scope presentation during the test revealed no echoes that could be positively distinguished from meteor trail returns. Later spectrum analysis with the Kay Vibralyzer allowed three of the recorded echoes to be clearly distinguished from returns from meteor trails.

The analysis is presented in the form of Vibragrams of the range gated zero frequency IF, that is, doppler frequency versus time plots with intensity of trace roughly proportional to signal level. The range gate length used for this study was approximately 30 miles in length. In the Vibragrams, the abscissa represents time and in each case displays a 20 second sample; the ordinate represents doppler frequency and the 250 cycle repetition rate line can be seen. Since the IF has been converted to zero frequency the doppler will appear symmetrically about the repetition rate line (and its harmonics). Figure 1 shows a typical 20 second period before $T_0$, and Figure 2 gives another analysis after $T_0$. These two figures show representative noise and meteor activity for the times of observation. Figures 3 and 4 show analyses of the three echoes that are considered to be reentry associated; these certainly cannot be construed as having normal meteor character. All three echoes appear in the same range gate when this gate is positioned 240 nm from NRL. The earliest echo began at $T_0$+338 seconds and lasts for about three seconds; during this interval the doppler change is from zero to about 90 cps. The second echo appears about 7 seconds later, starting with a near zero doppler and running to a maximum which is not too clearly displayed but which may be as high as 80 cps. The third echo appeared some 30 seconds after the first, that is, at $T_0$+368, and has a doppler history of running from near zero to about 60 cps during its 8 seconds duration. All three echoes have been interpreted as being associated with the 250 cps repetition rate line and therefore exhibit a relative acceleration even though they were certainly experiencing deceleration at the times observed.

NRL has operated an experimental HF radar during four previous Trailblazer launches, and a comparison of results can be made. Trailblazers 1C, 1D, 1E, and 1F are the prior firings observed, and each of these consisted of a six stage system with one high speed reentry body, a five inch sphere. Of these, 1C and 1E were detected; 1F went sufficiently off the expected course to be missed; and in the case of 1D the reentry body was nylon coated which may account for no detection. Spectrum analyses of 1C and 1E are given in Figures 5 and 6. Study of preflight data and some postflight data indicates convincingly that the target observed was in fact the high speed reentry body. These returns depicted in Figures 5 and 6 occurred at approximately $T_0$+369 seconds, and it is felt that the return of 1G shown in Figure 4 is from the 5 inch sphere on the basis of similar timing and rate.

It will be noted that the returns from Trailblazers 1C and 1E both showed relative deceleration whereas relative acceleration is shown for Trailblazer 1G. It is felt that this is just a result of different geometry. Trailblazers 1C and 1E were both detected at ranges under 200 nm from the NRL radar, and 1G was detected at 240 nm. Assuming that reentry ionization occurs in each case at the same altitude, the first two reentry ionizations occurred just prior to the point where the trajectory and radar path were normal thus giving relative deceleration, but the 1G reentry ionization, because of its greater distance from the radar, occurred just after the point where the trajectory and radar path were normal thereby showing relative acceleration. When post flight trajectory information becomes available, this explanation can be checked.

The third 1G echo has been discussed and compared with previous observations above; its doppler frequency range is not out of line with preflight predictions. The first 1G echo is assumed to come from the high speed pellet, and its reentry time of observation is within 2 seconds of predicted reentry. Its maximum doppler is about 90 cps indicating that its speed is 1.5 times that of the five inch sphere. According to preflight predictions this ratio is about 1.44. The second echo's origin is in some doubt, however, because of its frequency-time characteristics and its range, it is felt certain that it is associated with Trailblazer 1G. Trajectory uncertainties leading to antenna gain uncertainties discourage any estimating of radar cross section, however, the targets were easily discernible on a conventional A-Scope display.

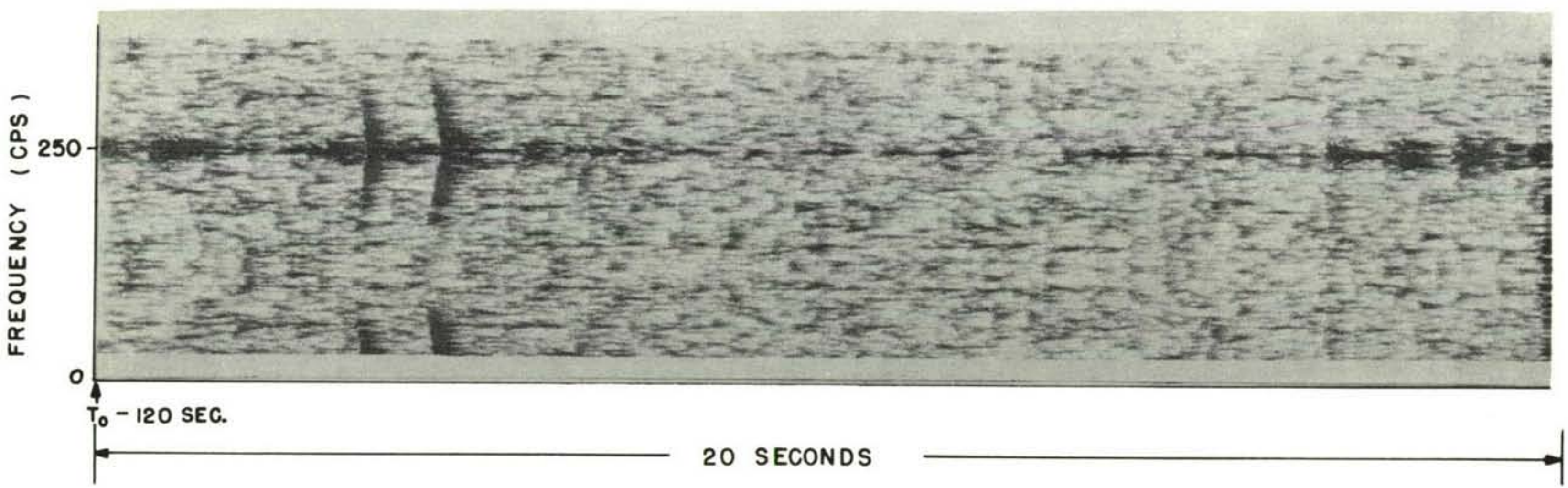


Fig. 1 - Typical meteors and noise before $T_o$

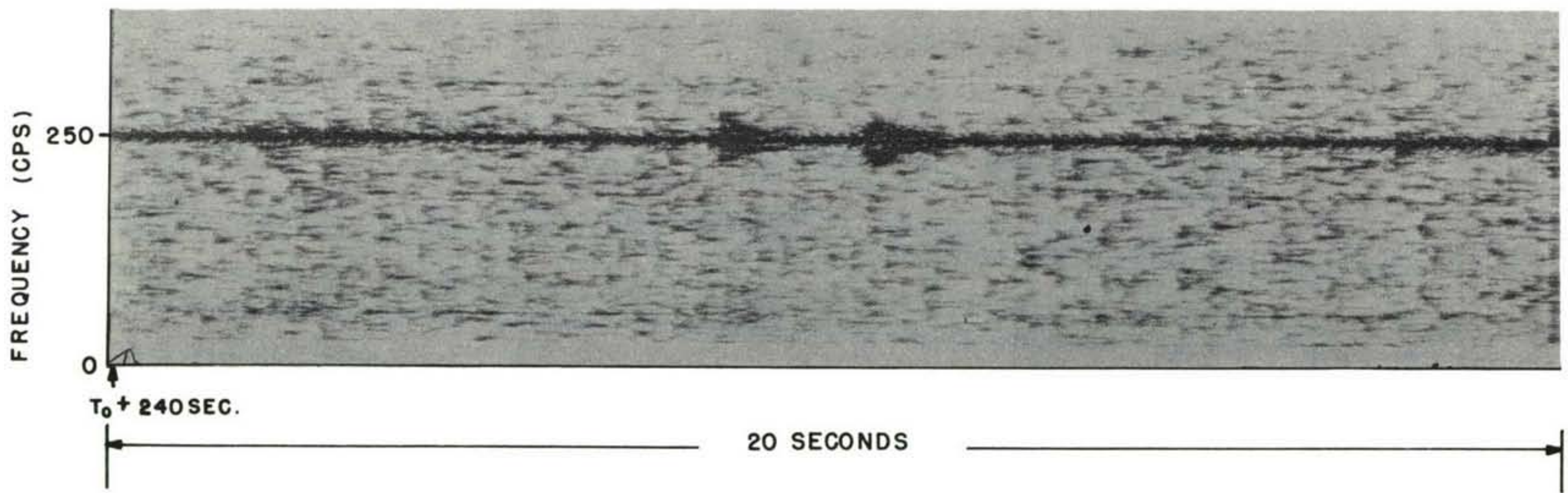


Fig. 2 - Typical meteors and noise after $T_o$

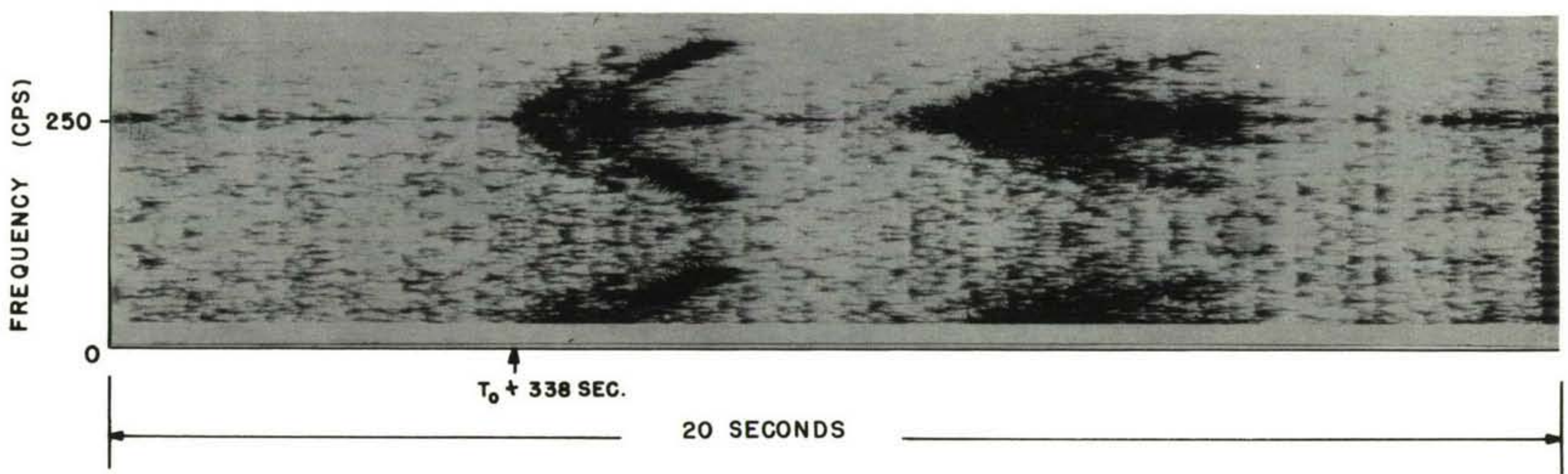


Fig. 3 - Trailblazer lg. range gate set on 240 n.mi.

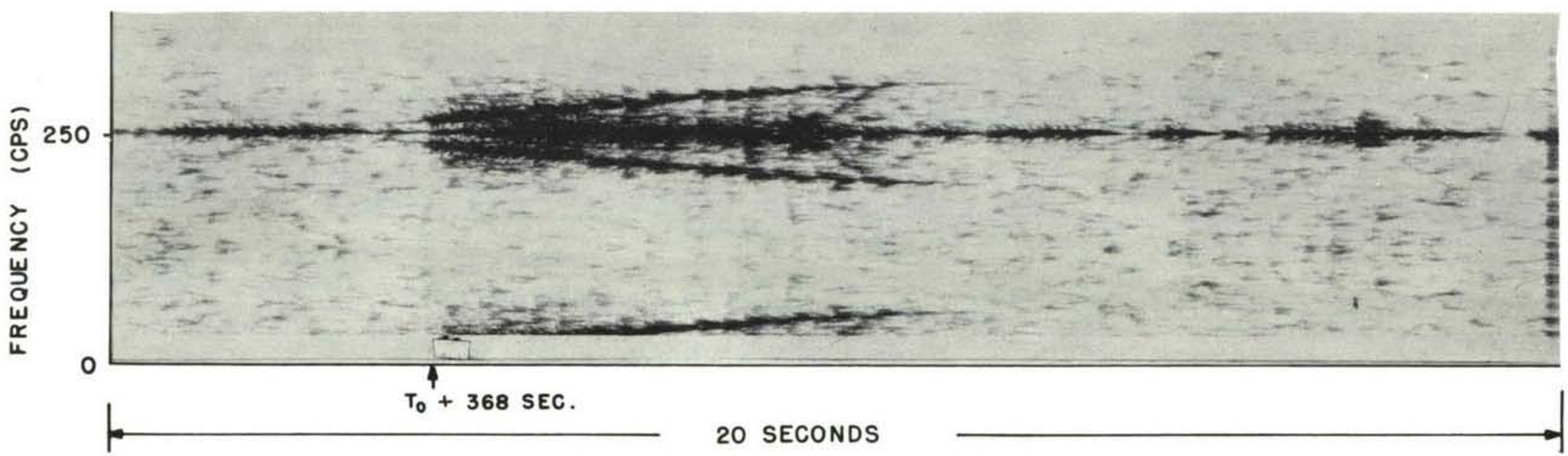


Fig. 4 - Trailblazer 1g. range gate 240 n.mi.

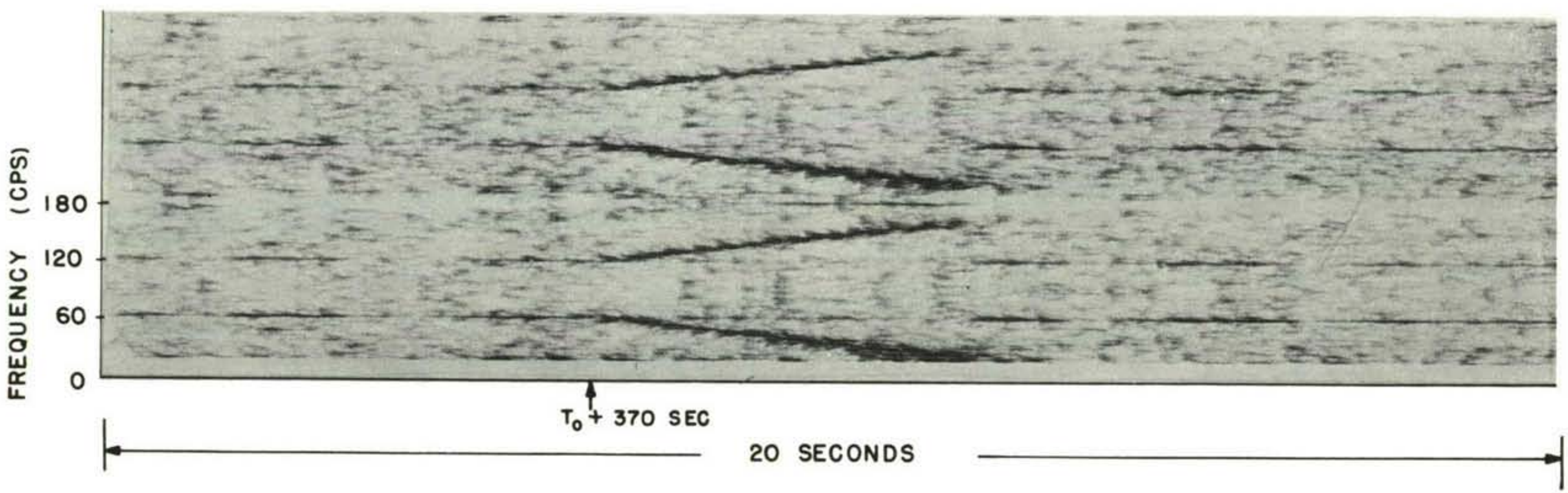


Fig. 5 - Trailblazer 1c.

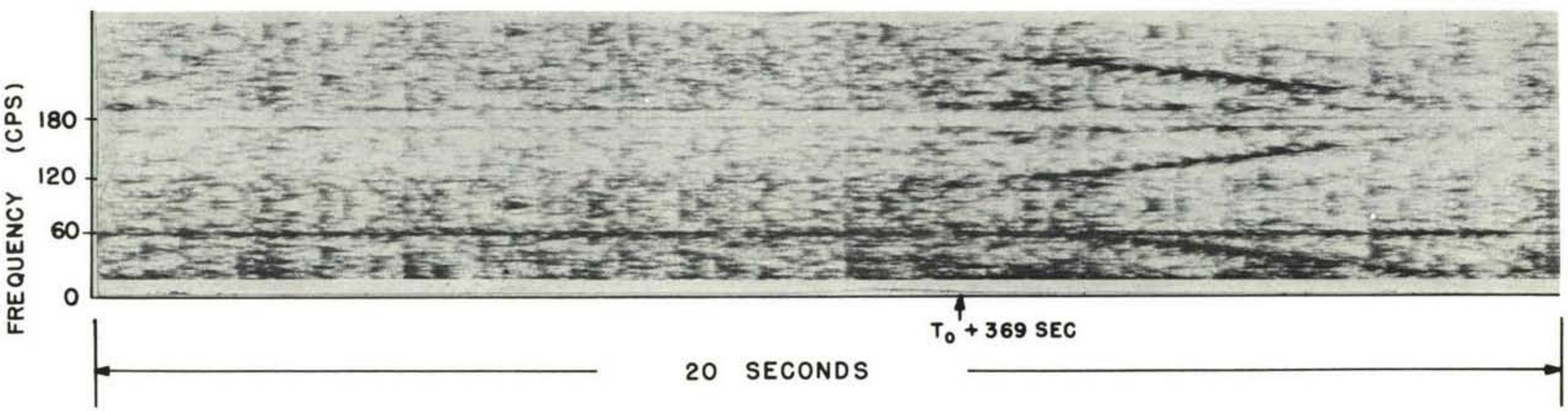


Fig. 6 - Trailblazer 1e. range gate at 193 n.mi.

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